to the electron orbitals of neighboring atoms in a crystal. Suppose aluminum oxide (colorless sapphire) is doped with 1% Cr_2O_3; each of the five 3d orbitals of the resulting Cr^{3+} ions is shifted, but not all by the same amount. Light of the proper color will cause transitions involving these split levels, and will therefore be absorbed. Two such resonance absorptions are in the violet and the green–yellow (broadened by vibrational interactions), leaving deep red and a little blue to pass through. As a result, we have the blood red of the ruby.

The spatial symmetry of the ligands causes resonances to differ along different axes. Therefore the color of the transmitted light will depend upon its plane of polarization, varying between purple-red and orange-red—an effect known as pleochroism. Increase the Cr_2O_3 doping to 10% and the ligand fields are weakened, giving a colorless crystal. Heat this crystal, reducing the fields still further, and a green color results, an effect known as thermochroism. Increasing the Cr_2O_3 concentration to 60% also produces a green color; but now subject the crystal to enormous pressures of, say, 100 kilobar, and the ruby red color returns—an effect called piezochroism.

I have minor disagreements with Nassau's placement of some topics. For example, the spectacular blue interference colors of the *Morpho* butterfly are described in the chapter "Colorants of Many Types," rather than in "Interference and Diffraction." Holography is treated in a hodge-podge chapter that includes the physiology and biochemistry of human vision; it, too, seems better suited to the chapter on "Interference and Diffraction." However, I cannot fault Nassau for omissions; this is the most complete book I know of at any level on the causes of color. There are extensive discussions of color produced by molecular vibrations and rotations, band gaps and charge transfer effects, interference, diffraction, dispersion and scattering—even 19 varieties of luminescence—to name but a few of the topics.

The Physics and Chemistry of Color is to be strongly recommended, both as a reference and as an ideal text for "special topics" classes on color.

DAVID G. STORK
Swarthmore College

book note

Newton at the Bat: The Science in Sports
Edited by Eric W. Schrier and William F. Allman
178 pp. Scribners, New York, 1984, $14.95

Why does a boomerang come back? This question and many others pertaining to the physics of sports are answered in this collection of essays that have been contributed to *Science 84* by a number of authors. The book is divided into four parts: "Balls and Other Flying Objects" discusses the physics of the motion of baseballs, golf balls, frisbees and the like; the second part, "Gear," deals with tennis racquets, bikes, skis, sails and gliders as viewed from the scientist's eye; the third part, "The Body," addresses the physiological aspects of sports, such as weight control, perspiration and the biophysical aspects of the exercising body; and the last part, "Form," is an amalgam of essays on subjects ranging from the ballistics of skiing to the construction of darts.

To those active in sports, *Newton at the Bat* will supply a theoretical backing that will make sports much more

enjoyable. More sedentary people, but lovers of theories, will also be fascinated by this book—and the varied and colorful collection of topics will perhaps induce them to leave their armchairs and try out some of those theories in the field. —AH

new books

Atomic, Molecular and Chemical Physics

Orienting Polymers. *Lecture Notes in Mathematics 1063.* Proc. University of Minnesota, Minneapolis, 1983, J. L. Ericksen, ed. 163 pp. Springer-Verlag, New York, 1984. $9.50

Rare Gas Solids. *Springer Tracts in Modern Physics 103.* H. Coufal, E. Lüscher, H. Micklitz, R. E. Norberg, 99 pp. Springer-Verlag, New York, 1984. $24.00

Swarms of Ions and Electrons in Gases. W. Lindinger, T. D. Märk, F. Howorka, eds. 311 pp. Springer-Verlag, New York, 1984. $31.50. *Compendium*

Kinetics of Heterogeneous Catalytic Reactions. M. Boudart, G. Djéga-Mariadassou, 222 pp. Princeton U. P., Princeton, N.J., 1984. $35.00 hardcover; $13.50 paper. *Monograph*

Wavefunctions and Mechanisms from Electron Scattering Processes. *Lecture Notes in Chemistry 35.* F. A. Gianturco, G. Stefani, eds. 279 pp. Springer-Verlag, New York, 1984. $19.70. *Compendium*

Quantum Chemistry of Polymers: Solid State Aspects. *NATO ASI Series.* J. Ladik, J-M. André, eds. 422 pp. Reidel, Boston, 1984. $59.00. *Compendium*

Isotope Shifts in Atomic Spectra. W. H. King, 208 pp. Plenum, New York, 1984. $37.50. *Monograph*

Electromagnetic Radiation Properties of Foods and Agricultural Products. N. N. Mohsenin, 673 pp. Gordon and Breach, New York, 1984. $99.00. *Monograph*

Multiphoton Spectroscopy of Molecules. S. H. Lin, Y. Fujimura, H. J. Neusser, E. W. Schlag, 260 pp. Academic, New York, 1984. $59.00. *Monograph*

Multiphoton Ionization of Atoms. S. L. Chin, P. Lambropoulos, eds. 272 pp. Academic, New York, 1984. $59.50. *Compendium*

Experimental Methods of Polymer Physics. A. Ya. Malkin, ed. 520 pp. Prentice-Hall, Englewood Cliffs, N.J., 1983. $38.95. *Compendium*

Student Texts and Popularizations

Lectures on Electromagnetic Theory. L. Solymar. 251 pp. Oxford U.P., New York, 1984. $18.95. *Undergraduate text*

Frozen Star. G. Greenstein. 274 pp. Freundlich, New York, 1984. $16.95. *Lay readers*

Improve Your Physics Grade. R. Aaron. 250 pp. Wiley, New York, 1984. $10.95. *Elementary text*

Physics. E. R. McCliment. 913 pp. Harcourt Brace Jovanovich, New York, 1984. $29.95. *Undergraduate text*

The Hidden Sun: Solar Eclipses and Astrophotography. J. Lowenthal. 107 pp. Avon Books, New York, 1984. $5.95 *Lay readers*

Astronomical Experiments. Third Edition. V. Icke. 198 pp. Burgess, Minneapolis, Minn., 1983. *Undergraduate text*

Atomic and Quantum Physics: An Introduction to the Fundamentals of Experiments and Theory. H. Haken, H. C. Wolf, 394 pp. Springer-Verlag, New York, 1984. $29.00. *Undergraduate text*

The Experience of Science: An Interdisciplinary Approach. M. Goldstein, I. Goldstein, 400 pp. Plenum, New York, 1984. $22.50

Time, Space and Things. Second Edition. B. K. Ridley, 177 pp. Cambridge U. P., New York, 1984. $29.95 hardcover; $9.95 paper. *Lay readers*

Theoretical Concepts in Physics: An Alternative View of Theoretical Reasoning in Physics for Final-year Undergraduates. M. S. Longair, 366 pp. Cambridge U. P., New York, 1984. $49.50

Relativity Physics. *Student Physics Series.* R. E. Turner, 141 pp. Routledge, Boston, 1984. $9.95. *Undergraduate text*

Electricity and Magnetism. *Student Physics Series.* E. R. Dobbs, 122 pp. Routledge, Boston, Mass., 1984. $9.95. *Undergraduate text*

Classical Mechanics. *Student Physics Series.* B. P. Cowan, 111 pp. Routledge, Boston, 1984. $9.95. *Undergraduate text*

Essential Mathematics for College Physics with Calculus: A Self Study Guide. M. Ram, 418 pp. Wiley, New York, 1984. $12.95

A Workbook for Astronomy. J. Waxman, 356 pp. Cambridge U. P., New York, 1984. $19.95. *Undergraduate text*

Computing in Applied Science. W. J. Thompson, 325 pp. Wiley, New York. $26.95. *Introductory text*

Miscellaneous

Nuclear War: The Medical and Biological Consequences, Soviet Physicians' Viewpoint. Y. I. Chazov, L. A. Ilyin, A. K. Guskova, 238 pp. Novosti, Moscow, 1984.

Indirect Imaging: Measurement and Processing for Indirect Imaging. Proc. of The International Symposium, Sydney, Australia, August–September 1983. J. A. Roberst, ed. 439 pp. Cambridge U. P., New York, 1984. $54.00

Collected Works of Meghnad Saha, Vol. 1. S. Chatterjee, ed. 591 pp. Orient Longman, Bombay, 1982. Rs 75.00

Patent and Trademark Tactics and Practice. Second Edition. D. A. Burge, 213 pp. Wiley, New York, 1984. $29.95

Metaphoric Process: The Creation of Scientific and Religious Understanding. M. Gerhart, A. M. Russell. 217 pp. Texas Christian U.P., Forth Worth, Tex., 1984. $16.95 cloth; $10.95 paper □